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54 Apparatus for and method using the apparatus for the encapsulation of electronic modules.

57 An induction heating module encapsulation apparatus and method for its use is disclosed. The apparatus comprises a substantially airtight chamber which is composed of ceramic or some other high temperature insulating material in which a cap (15) and a ceramic substrate (13) having semiconductor chips (11) joined thereon are placed. A sealband (17) of solder or other brazing material is placed at the periphery of the cap where the cap and substrate are to be joined. An RF coil (39), which serves as inductor in the apparatus, is energized by a high frequency generator, generating an electromagnetic field in the radio frequency spectrum. The RF coil is oriented to localize the induced current at the periphery of the cap and the sealband. The induced current is dissipated in the form of heat until the sealband is molten. The RF power is then turned off. The chamber is pressurized at this point to prevent heated air underneath the cap from breaching the integrity of the sealband by escaping through the sealband while it is in its molten state. After the sealband has been allowed to cool sufficiently to solidify, the pressure is reduced and the completed module is removed from the chamber. The entire encapsulation process requires ten to fifteen seconds per module assembly.

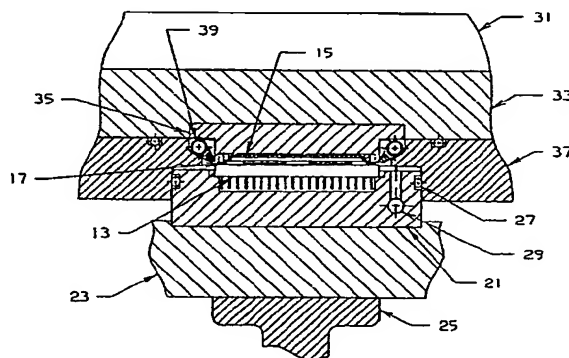


FIG. 3

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APPARATUS FOR AND METHOD USING THE APPARATUS FOR THE ENCAPSULATION OF MODULES

The present invention relates to the encapsulation of semiconductor chips on ceramic modules with a protective cap.

In the fabrication of a modern computer, one or more semiconductor chips which provide the main logic and memory circuits for the computer are electrically connected to a ceramic substrate. The ceramic substrate is in turn electrically connected to a printed circuit board and several circuit boards in the computer.

Before the ceramic substrate is mounted on the circuit board, it is encapsulated by covering the semiconductor chips on the substrate with a protective cap, generally composed of a metallic material, which is bonded to the periphery of the ceramic substrate. The assembled ceramic substrate and metallic cap combination is called a module or module assembly. In the prior art, the encapsulation process requires large and expensive tooling, as well as a considerable amount of process time and operator attention. To attach a metallic cap to the ceramic substrate, a metallic sealband, typically of tin solder, silver solder or other suitable brazing material, is applied to the periphery of the substrate. The sealband must be flattened by placing a ceramic weight on the sealband and running the substrate-weight combination through a finely controlled furnace. Next, after removing the ceramic weight, a thermal paste is dispensed into the cap. A capping tool then positions the metallic cap onto the substrate. The thermal paste acts as a thermal bridge between the semiconductor chips on the substrate and the cap to aid in heat dissipation through the cap. A capping fixture is then attached around the cap and substrate to apply the necessary pressure for the bonding operation. The substrate-cap-capping fixture combination is subsequently run through another finely controlled conveyor furnace with an inert atmosphere. In the prior art method, the bonding operation is quite slow as both the module assembly and the capping fixture must be heated to the reflow temperature by means of convection heating. After the module is assembled, it undergoes a series of electrical and physical tests to determine whether all components are operating and have been assembled correctly. Occasionally, a module fails testing. The failed module is then disassembled by running through the conveyor furnace and those parts which are fully functional are salvaged for other modules.

The prior art encapsulation process described above is time consuming, expensive, and requires a significant amount of floor space in the semiconductor fabrication line. For example, a single con-

veyor furnace approx. measures 7.26 m long by 0.91 m wide, and 1.52 m high, requires constant temperature profiling throughout its lifetime. The combined sealband flattening and module bonding processes in such a furnace require an average of 40 minutes for each module. The furnaces, once profiled, remain continuously powered and are continuously purged with nitrogen or another inert gas; over time, both the power and purging gas represent significant operating costs. Further, as floor space on a semiconductor fabrication line is generally figured at \$100 per square foot per annum, the size of the tool alone represents a significant cost factor. Adding yet further to the costs of the prior art encapsulation method are the multitude of capping fixtures which must be built to obtain a sufficiently high throughput. The capping fixtures must be specially made for each type of module assembly manufactured in the line.

Finally, in addition to the cost problems associated with the prior art process discussed above, as the entire module assembly heats up, there is a potential manufacturing problem: the solder connections which hold the semiconductor chips to the ceramic substrate could reach a sufficiently high temperature to melt. Thermal fatigue is a particular problem when the module is reworked several times.

Thus the invention as claimed is intended to remedy these drawbacks. It is therefore an object of the present invention to enhance the encapsulation operation.

These objects and others are achieved by an apparatus and improved method for module encapsulation by induction heating. The apparatus has a substantially airtight chamber in which the ceramic substrate and cap are placed. A radio frequency (RF) coil, acting as the inductor in the apparatus, is oriented so that the RF current induced in the cap is localized at the lip of the cap and the sealband area. A gas inlet port is connected to the chamber to compensate for the increase in air pressure from heated air under the cap to preserve the integrity of the molten sealband.

In the preferred embodiment, the encapsulation apparatus is constructed in two major assemblies, a stationary upper assembly which includes an RF coil to provide the induction heating effect and a lower assembly having a insulator nest composed of a ceramic or other high temperature insulator, in which the ceramic substrate and cap are placed. The ceramic nest rests on a tool lift carriage which lifts and lowers the entire lower assembly to contact and disengage from the upper assembly. The components of the upper assembly are mounted

on a rigid tool frame. In addition to the RF coil, the upper assembly comprises a chamber plate, a ceramic upper pressure plate and an insulator plate. When the lower assembly is lifted to the closed position in contact with the upper assembly, the ceramic nest mates with the chamber plate and the ceramic upper pressure plate to form a small chamber in which the bonding process takes place. The ceramic upper pressure plate contacts the cap and provides the pressure necessary to assure a good bond with the substrate. Once the solder sealband has been melted by the RF current inducted into the cap and sealband by the RF coil.

The improved encapsulation method commences with placement of a ceramic substrate and metallic cap in the ceramic nest of the lower assembly while the apparatus is in an opened position. The ceramic substrate is provided with a sealband, preferably made of a solder-like material. The lower assembly is lifted into a closed position so that the ceramic nest is mated with the chamber plate and the ceramic upper pressure plate presses against the metallic cap. The RF coil is energized and produces an electromagnetic field which induces a current in the metallic cap, and sealband if the sealband is composed of a metallic material. The sealband is melted by the heated cap within a few seconds. When the reflow temperature of the sealband is reached, the RF coil is turned off. As the air trapped inside the cap is also heated, pressurized nitrogen, or another gas, is introduced to pressurize the chamber, equalizing the pressure on each side of sealband and thereby maintaining the integrity of the sealband. Within a few seconds, the module assembly is lowered to the opened position and the completed module is removed from the apparatus.

With a respective apparatus it is possible to disassemble a ceramic module assembly which has been joined by a solder sealband through the use of RF induction heating. The apparatus for disassembling as claimed, comprises an RF coil oriented around an area where said cap is in contact with said sealband, said RF coil generates an electromagnetic field in RF frequency current into said cap and said sealband until said sealband is molten; and, means to separate said cap from said substrate when said sealband is molten.

Advantageously the present invention reduces the process time and costs for an encapsulation operation. Further it eliminates the need for large, expensive conventional furnace in the module encapsulation process.

It is a further advantage of the present invention to eliminate the need for specialized capping fixtures and capping tools in an improved encapsulation method, to reduce the energy and purging gas requirements for a module encapsulation op-

eration, and to reduce the semiconductor line floor-space required for the tooling associated with an encapsulation operation.

The above as well other objects and features of the present invention will be more clearly understood by reference to preferred embodiments which are described in the following with reference to the accompanying figures, in which:

Fig. 1 is a perspective view of a completed ceramic module assembly including a ceramic substrate and semiconductor chips and metallic cap mounted thereto;

Fig. 2 is a cross sectional view of the RF encapsulation apparatus in the opened position;

Fig. 3 is a cross sectional view of the RF encapsulation apparatus in the closed position;

Fig. 4 is a perspective view of the RF coil in the RF encapsulation apparatus; and

Fig. 5 is a cross sectional view of a slightly modified version of the RF encapsulation apparatus to be used for disassembly of a completed ceramic module assembly.

Induction heating is a method of raising the temperature of an electrically conductive material. Based on the 1831 discoveries of Michael Faraday, the temperature of a conductive material can be raised by subjecting it to an alternating electromagnetic field. The electrical currents induced in the conductive material dissipate power in the form of heat. A water filled coil, or inductor, acts as the primary winding of a transformer and surrounds the material to be heated which acts as the secondary winding. Alternating currents flowing in the primary coil induce eddy currents in the conductive material causing it to be heated. The depth to which the eddy currents penetrate the conductive material depends on a complex relationship between the frequency of the alternating current in the inductor, the workpiece dimensions, and the magnetic permeability and resistivity of the conductive material.

For soldering or brazing applications such as the encapsulation process of the present invention, it is known that an alternating electromagnetic field in the radio-frequency (RF) spectrum of between 50kHz to 10MHz is most suitable. In such an induction heating system, an RF coil is used as the inductor to produce very shallow eddy current depths (0.1 to mm) and localized heating at fast rates. In general, the higher the RF frequency, the shallower the eddy current and the more localized the heating effect. A more complete understanding of the physics of induction heating is found in the Inducting Heating Handbook, by John Davies and Peter Simpson, McGraw-Hill, London, 1979. chapters of particular relevance for the present invention include chapters 1, 4, 9, 12 and 13.

Referring to FIG. 1, a perspective view of a completed ceramic module assembly 10 depicted.

Semiconductor chips 11 are electrically connected to the top of the ceramic substrate 13 by means of small solder balls. The solder balls are attached to pads on both the chips 11 and substrate 13. For more information on the joining process between the semiconductor chips and the ceramic substrate, refer to commonly assigned U.S. Patent No. 4,360,142 entitled "Method of Forming a Solder Interconnection Capable of Sustained High Power Levels Between a Semiconductor Device and a Supporting Substrate". The protective cap 15 is bonded to the periphery of the top of the substrate 13 by means of a sealband 17. The ceramic substrate 13 typically has a metallization feature on its top surface shaped like the sealband 17 and lip of the cap 15 to assure a good bond. The sealband 17 is preferably composed of a solder-like material, for example, a lead-tin or silver solder, and can be made of any brazing material compatible with the module assembly. The substrate 13 and cap 15 depicted in FIG. 1 measure 50mm by 50mm, however, the present invention can readily be adapted to smaller and larger modules. A thermal paste provides a thermal bridge between the semiconductor chips 11 and the cap 15. On the bottom of the ceramic substrate 13, connector pins 19, numbering approximately a hundred or more, are fixed to provide electric contact from the ceramic substrate 13 to a circuit board (not shown). The present invention will perform equally well with a substrate composed of a conventional ceramic material or the newer glass-ceramic materials to which the semiconductor industry is evolving. In the nomenclature of the present application, the term "ceramic" is used to be inclusive of both these types of substrates.

In theory, the induction heating effect of the present invention could be used with a nonmetallic cap, inducing the RF current into the sealband 17 alone. In practice, because of concerns of the effects of RF field on the circuitry in the semiconductor chips 11 and ceramic substrate 13, it is preferable to use a weaker RF field and rely on the induction heating effects of the field on cap 15 of which at least the cap lip is metallic. The heat generated in the cap 15 will flow to help the sealband 17 reach reflow temperature. In addition, the use of a metallic cap 15 shields the semiconductor and substrate circuitry from the RF induced field. When a metallic cap or a cap with a metallic lip is used, it is possible to use a thermoplastic, epoxy-based plastic alloy, or other polymer material for the sealband 17. The heat generated by the RF current induced in the cap 15 can conduct heat to the polymer sealband 17 until it reaches its reflow temperature, despite the fact that no current is induced in the sealband 17 itself. The use of a polymer material for the sealband would have the

advantage of a lower melting point or reflow temperature, thus further reducing the chance of affecting the solder joints between the substrate 13 and the chips 13. The main disadvantages associated with a polymer sealband are compatibility issues with the other materials in the module assembly 10.

In Fig. 2, a cross section view of the RF encapsulation apparatus in the opened position is shown. The apparatus is quite compact; with the RF generator and the heat exchanger (both not shown), it measures approximately 0.91 m wide by 0.61 m in depth by 0.76 m high. The apparatus replaces three conveyor furnaces which would require about 46.5 square meter in floor space, realizing a great savings in floor space in the semiconductor line. Ceramic substrate 13 and cap 15 are shown positioned in the ceramic nest 21 is removable from lower assembly 20. An O-ring 27 helps seal the chamber when the RF encapsulation apparatus is in the closed position, and a gas inlet port 29 which provides a pressurized gas mixture to the chamber during the bonding process are also shown in the lower assembly 20.

The upper assembly 30 of the RF encapsulation apparatus is anchored by the tool frame 31 to which the other components are mounted. The insulator plate 33 is attached directly to the bottom of the tool frame 31. Attached to the bottom of the insulator plate 33 is the ceramic upper pressure plate 35 and the chamber plate 37. Also included in the upper assembly is an RF coil 39 in the encapsulation apparatus which induces the RF current into the lip of the cap 15 located over the sealband 17. The ceramic upper pressure plate 35 is located over the lip of the cap 15. The ceramic upper pressure plate 35, like the ceramic nest 21, is reconfigured for each size and type of substrate 13 and cap 15 to be encapsulated. If the difference in the size of the various substrates is great, then the RF coil 39 will also be replaced to assure that the RF current will be concentrated in the sealband 17 area. The nest 21, upper pressure plate 35 and chamber plate 37 are not necessarily composed of the ceramic material, but they must be made of an insulator material to avoid coupling with a RF coil 39. The insulator also must be able to withstand the temperatures of 200 to 300 degrees centigrade needed to reach the reflow temperature of a solder sealband 17. The insulator plate 33 is not subjected to these temperatures and can be readily be made of a relatively low melting plastic.

The RF encapsulation apparatus cross section in the closed position is depicted in Fig. 3. The ceramic nest 21 mates with the ceramic upper pressure plate 35 and the chamber plate 37 to form the small chamber in which the bonding process takes place. The O-ring 27 helps seal the

chamber. When the lower assembly 20 is lifted in place, the ceramic upper pressure plate 35 provides the pressure on the metal cap 15 necessary to create a good bond at the sealband 17, thus eliminating the need for the multitude of specialized capping fixtures and capping tools associated with prior art encapsulation processes. Depending on the size of the cap 15 and substrate 13, the necessary clamping force exerted by the ceramic upper pressure plate 35 is in the range of 4 to 30 kilograms.

After the lower assembly 20 is lifted to the closed position, RF current from a high frequency generator (not shown) is supplied to the RF coil 39. In the preferred embodiment of the invention the apparatus operates at an RF frequency of between 400kHz to 600kHz, at approximately 2000 volts and at a power of 2 kilowatts. In this embodiment, the cap 15 is made of a low expansion alloy such as Invar, a steel alloy made of 63.7% iron, 36% nickel, and 0.3% molybdenum, clad in inner and outer layers of copper. Including the copper cladding, the lip of a 50 mm by 50 mm cap measures approximately 0.66mm in thickness. The sealband 17 is composed of 60/40 lead/tin solder which has a reflow temperature of 194°C and is 152 µm in thickness. The clamping force for a 50mm by 50mm cap 15 and substrate 13 is on the order of 17-20 kilograms. The RF current is induced into the metallic cap 15 and solder sealband 17. The sealband 17 is melted within a few seconds, largely from the heat generated in the metallic cap 15 and conducted into the sealband 17 by heat transfer effects. The solder sealband 17 bonds to the metallization feature of the ceramic substrate 13 and the metallic lip of the cap 15. One skilled in the induction heating art would recognize that the choice of cap and sealband material, the size of the cap 15 and the configuration of the RF coil 39 and its concentrator 43 can have a large effect on the choice of these parameters. When the reflow temperature is reached, the RF generator is turned off.

As the air trapped inside the cap 15 is also heated, it has a tendency to expand. Since the cap 15 is held in place by the pressure plate 35, the only place for the air to escape is through the molten solder sealband 17. The escape of the air will create a small hole or series of small holes in the sealband 17 if not prevented. Holes in the sealband 17 are normally not acceptable as one of the prime functions of the cap 15 is to prevent the environment from coming in contact with the semiconductor chips 11. The water vapor and oxygen present in air would cause corrosion and other reliability problems. To eliminate such blow holes, in the preferred embodiment, a pressurized inert gas of about 41 to 55 kPa is purged through the

gas inlet port 29 to equalize gas pressure on both sides of the sealband 17 until it has solidified. For the purposes of the present invention, an inert gas is one which will not react with the solder 17, or other materials on chips 11 and substrate 13 such as nitrogen, helium or argon.

If the gas is introduced after the sealband 17 is molten, but before any blowholes are created, it is not necessary that the gas be inert as the chips 11 and substrate 13 are already sealed from the environment by the molten sealband 17. However, an inert gas is preferred if the gas is to be or could possibly be introduced before the sealband is molten. After a few seconds, the sealband 17 has cooled sufficiently to solidify and the gas pressure is released. Although the gas inlet port 29 is located in the ceramic nest 21 in this particular embodiment, its exact placement is not material to the invention so long as access to the chamber is provided. For example, to automate the placement of the substrate 13 and cap 15 on the lower assembly it might be desirable to utilize a plurality of ceramic nests 21 as removable fixtures which accompany the module assembly 10 through the line. The gas inlet port 29 would be located in the chamber plate 37 in such an automated embodiment.

After the pressure is released, the lower assembly 20 is lowered and the finished module assembly 10 is unloaded from the RF encapsulation apparatus. Although the throughput of the encapsulation apparatus is dependent on a number of factors including the size of the substrate 13, cap 15 and sealband 17, the power of the RF current supplied to the RF coil 39 and the brazing material used in the sealband 17, normal cycle time for a single module assembly following the preferred embodiment described above would be on the order of 10 to 15 seconds.

This is far faster than the 25 to 30 minutes required for bonding by the prior art methods. Also, the present invention does not require the sealband flattening operation of the prior art which required an additional 15 to 20 minutes and its own specialized ceramic weights.

Fig. 4 shows a perspective view of the RF coil 39 used in the preferred embodiment of the encapsulation apparatus. The RF coil 39 portrayed in Fig. 4 is a single turn coil made of a copper ring concentrator 43 brazed on a coil of copper tubing 44. A multiple turn coil could be used according to the principles of the present invention and would have an added advantage of not requiring an RF matching transformer required by the single turn coil coupled to the RF generator (both not shown). However, the single turn coil 39 is easier to incorporate and seal in the encapsulation apparatus. Flare nuts 41 connect the RF coil 39 to the RF

generator output.

Without water or other coolant flowing through the coil tubing 44, there is a danger of the RF coil 39 overheating and melting. The concentrator 43 focuses the RF current to the lip of the cap 15 and the sealband 17. The RF coil concentrator 43 is necessary for accurate distribution of the RF current to the lip of the cap 15 for uniform heating for the sealband 17 to control the solder flow and assure a uniform solder distribution. Without the concentrator 43, the magnetic field would be more dispersed, creating a greater chance of the circuitry on the chip 11 and substrate 13 to be affected. The concentrator 43 has a gap 45 to prevent shorting in the RF coil 39.

Fig. 5 shows a modified RF encapsulation tool which can be used to disassemble a completed module assembly 10 which as failed electrical or physical testing. Most of the configuration remains the same as that shown in Figs. 2 and 3 except that the chamber plate 37 and O-ring 27 are no longer needed as the integrity of the sealband 17 is not an issue on rework of the module. The ceramic pressure plate 35 is also not required to provide pressure on the cap 15 and is modified to accept a central holder 51 which retains the cap 15 after the sealband 17 has been melted by the RF coil 39. The holder 51 could be a magnet for ferrous-based caps or a vacuum holder for non-ferrous caps.

The operation of the modified tool shown in Fig. 5 is similar to that described above in conjunction with Figs. 2 and 3. In this case, however, a completed module assembly 10 is placed in the ceramic nest 21, rather than an unbonded substrate and cap used above. The lower assembly 20 is raised until the cap 15 is in contact with the holder 51 and the pressure plate 35. In this embodiment, the pressure plate 35 primarily fulfills a positioning function for the sealband 17 with respect to the RF coil 39. The RF coil 39 is energized by the high frequency generator and melts the sealband 17. The holder 51 prevents the cap 15 from descending with the substrate 13 and separation of the module assembly is accomplished. After the substrate 13 is removed, the holder 51 can be lowered to allow for easier removal of the cap 15.

Other chamber and RF coil designs are possible; there is no necessity that the RF coil be part of an upper assembly so long as the RF field is concentrated at the lip of the cap and sealband.

Claims

1. An apparatus for encapsulating a ceramic substrate having semiconductor chips (11) joined thereon with a protective cap (15) through the use

of RF induction heating to melt a sealband (17) placed between said cap and said substrate near the periphery of said cap, said apparatus connected to a source of RF power, comprising:

5 a substantially airtight chamber constructed from a high temperature insulator material in which said cap is positioned on said ceramic substrate;
a means (35) for forcing said cap and said substrate together to promote good bonding upon said melting of said sealband;
10 an RF coil (39) connected to said source of RF power oriented around the periphery of said cap which generates an electromagnetic field in the RF frequency spectrum to induce a current in said
15 cap, said forcing means urging said cap into thermal contact with said sealband, until said sealband is molten; and

a gas inlet port (29) connected to said chamber to pressurize said chamber to prevent heated air inside said cap from breaching the integrity of said sealband.

2. The apparatus as recited in claim 1 wherein said electromagnetic field induces a current in said sealband in addition to said current induced in said cap.

3. The apparatus as recited in claim 1 wherein said protective cap is composed of metallic material.

4. An apparatus for encapsulating a ceramic substrate having semiconductor chips (11) joined thereon with a protective cap (15) through the use of RF induction heating to melt a solder sealband (17) placed between said cap and said substrate near the periphery of said cap, said apparatus connected to a source of RF power, comprising:

35 a substantially airtight chamber constructed from a high temperature insulator material in which said cap is positioned on said ceramic substrate;
a means (35) for forcing said cap and said substrate together to promote good bonding upon said melting of said solder sealband;
40 an RF coil (39) connected to said source of RF power oriented around the periphery of said cap which generates an electromagnetic field in the RF frequency spectrum to induce a current in said
45 sealband until said solder sealband is molten; and
a gas inlet port (29) connected to said chamber to pressurize said chamber to prevent heated air inside said cap from breaching the integrity of said sealband.

5. The apparatus as recited in claim 4 wherein said protective cap is composed of non-metallic material.

6. The apparatus as recited in any one of the preceding claims wherein said RF coil is comprised of copper, said RF coil having a concentrator which localizes said electromagnetic field at the periphery of said cap and said sealband to reduce power requirements and the effects of the elec-

tromagnetic field on circuitry on said substrate.

7. The apparatus as recited in any one of the preceding claims wherein said chamber is pressurized with an inert gas.

8. The apparatus as recited in any one of the preceding claims wherein said chamber is fabricated of a ceramic material having a concave shape to fit around said cap and said substrate, and wherein said forcing means is a ceramic upper pressure plate (35) which contacts the periphery of said cap.

9. The apparatus as recited in any one of the preceding claims wherein said apparatus is arranged in an upper (30) and a lower (20) assembly, said lower assembly comprising:

a ceramic nest (21) in which said cap and said substrate are positioned in a depression on a top face of said ceramic nest;

a lifting means to lift said ceramic nest to mate with said upper assembly in a closed position; and, said upper assembly comprising:

said RF coil;

a ceramic chamber plate (37) which mates with said ceramic nest when said ceramic nest is in said closed position;

said forcing means, wherein said means for creating pressure is a ceramic upper pressure plate, said upper pressure plate providing a force down on said cap when said ceramic nest is in said closed position; and,

wherein said ceramic nest, said ceramic chamber plate and said ceramic upper pressure plate form said substantially airtight chamber when said ceramic nest is in said closed position.

10. A method for encapsulating a ceramic substrate having semiconductor chips joined thereon with a protective cap through the use of RF induction heating to melt a sealband placed between said substrate and said cap near the periphery of said cap, comprising the steps of:

positioning said cap over said substrate so that said sealband is in contact with said cap near its periphery;

placing said cap and said substrate in a substantially airtight chamber;

forcing said cap and said substrate together to promote a good bond between said cap and said substrate, simultaneously forcing said cap in thermal contact with said sealband;

inducing a current in said cap with an electromagnetic field in the RF spectrum, thereby heating said cap by induction heating and said sealband by heat transfer from said cap until said sealband melts, or inducing a current in said sealband with an electromagnetic field in the RF spectrum, thereby melting said sealband by induction heating; and, creating air pressure within said chamber to prevent heated air within said cap from breaching the

integrity of said molten sealband until said sealband cools and solidifies.

11. The method as recited in claim 10 wherein said electromagnetic field is concentrated at at said cap or at said sealband and at said cap, respectively, near its periphery to reduce power requirements and effects of said electromagnetic field on circuitry on said substrate.

12. The method as recited in claim 10 or 11 wherein said protective cap is composed of a metallic or non-metallic material, respectively.

13. The method as recited in any one of the preceding claims 10 to 12 wherein said air pressure is created by introducing an inert gas into said chamber.

14. The method as recited in claim 10 and 12 wherein a current is induced in said sealband as well as in said metallic cap by said electromagnetic field.

15. An apparatus for disassembling a ceramic module assembly, said ceramic module assembly comprising a protective cap and ceramic substrate joined by a solder sealband, through the use of RF induction heating to melt said sealband, said apparatus connected to a source of RF power, comprising:

an RF coil oriented around an area where said cap is in contact with said sealband, said RF coil generates an electromagnetic field in RF frequency current into said cap and said sealband until said sealband is molten; and,

means to separate said cap from said substrate when said sealband is molten.

16. The apparatus as recited in claim 15 wherein said RF coil has a concentrator which localizes said RF field in the area where said solder sealband joins said cap.

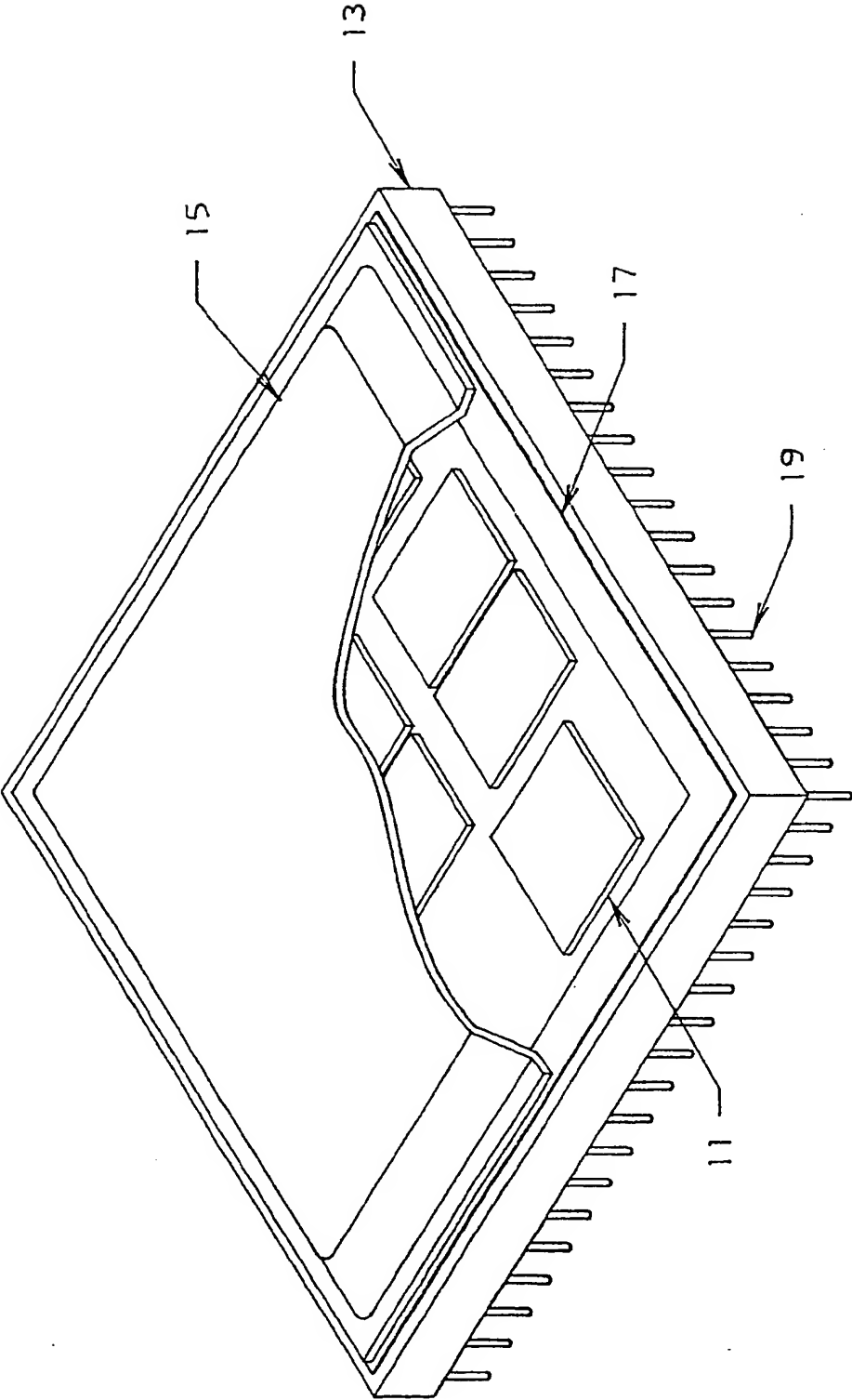


FIG. 1

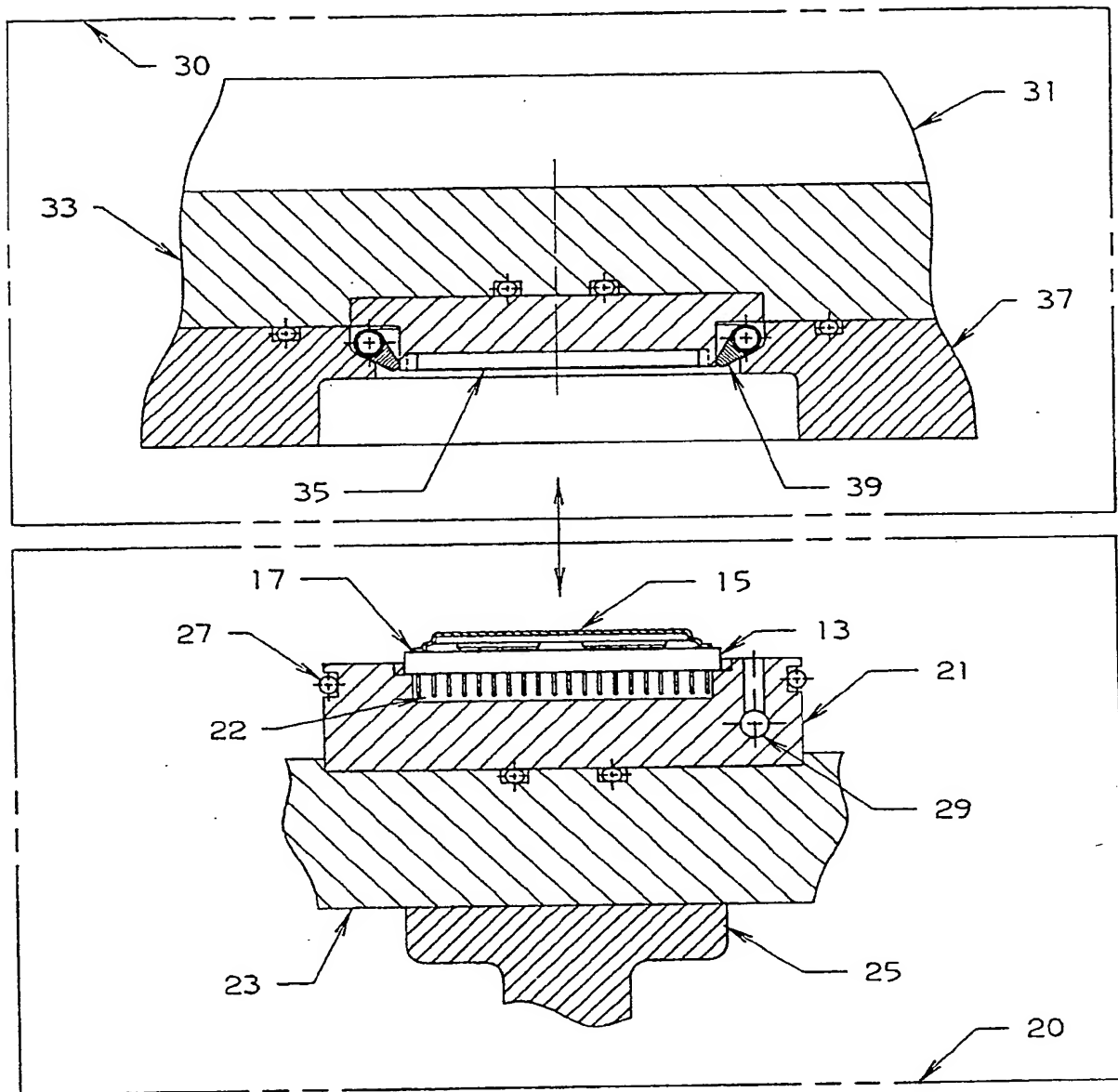


FIG. 2

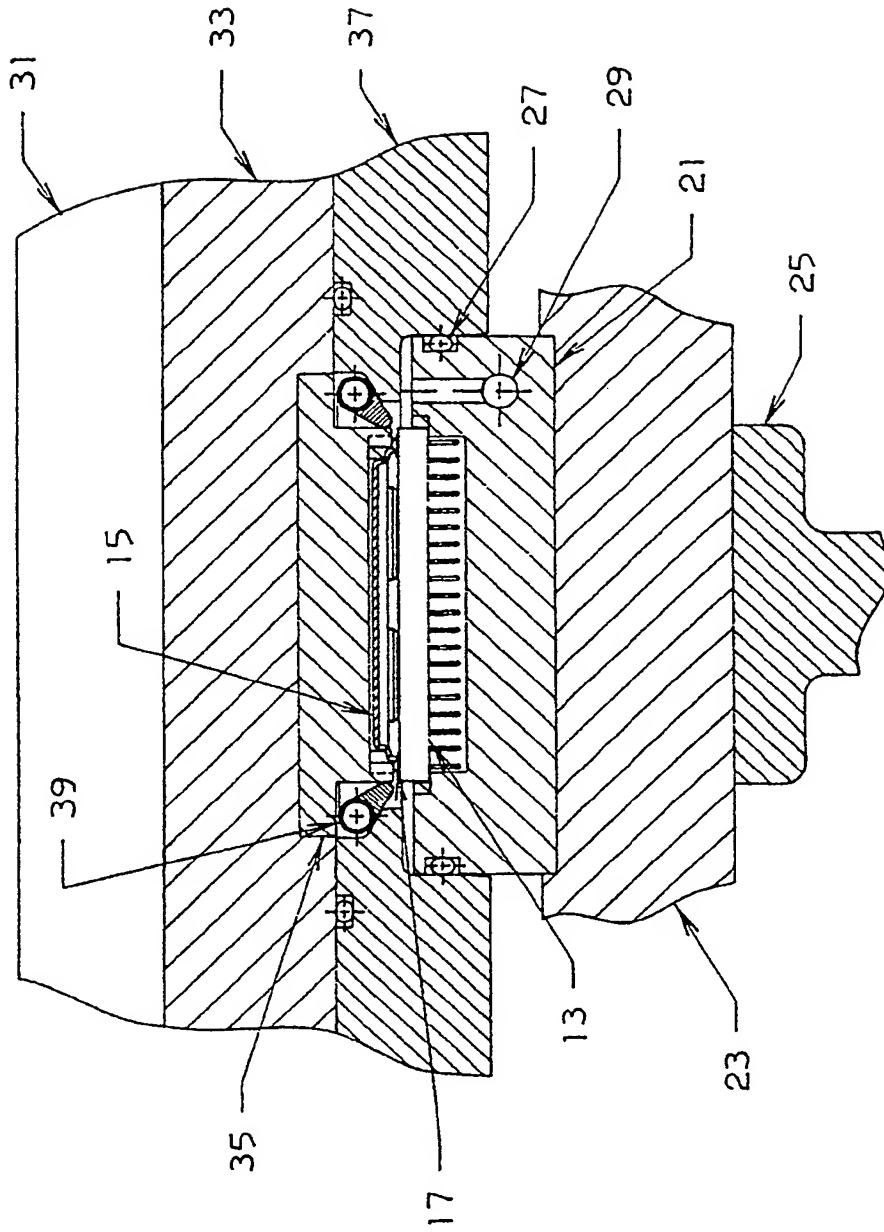
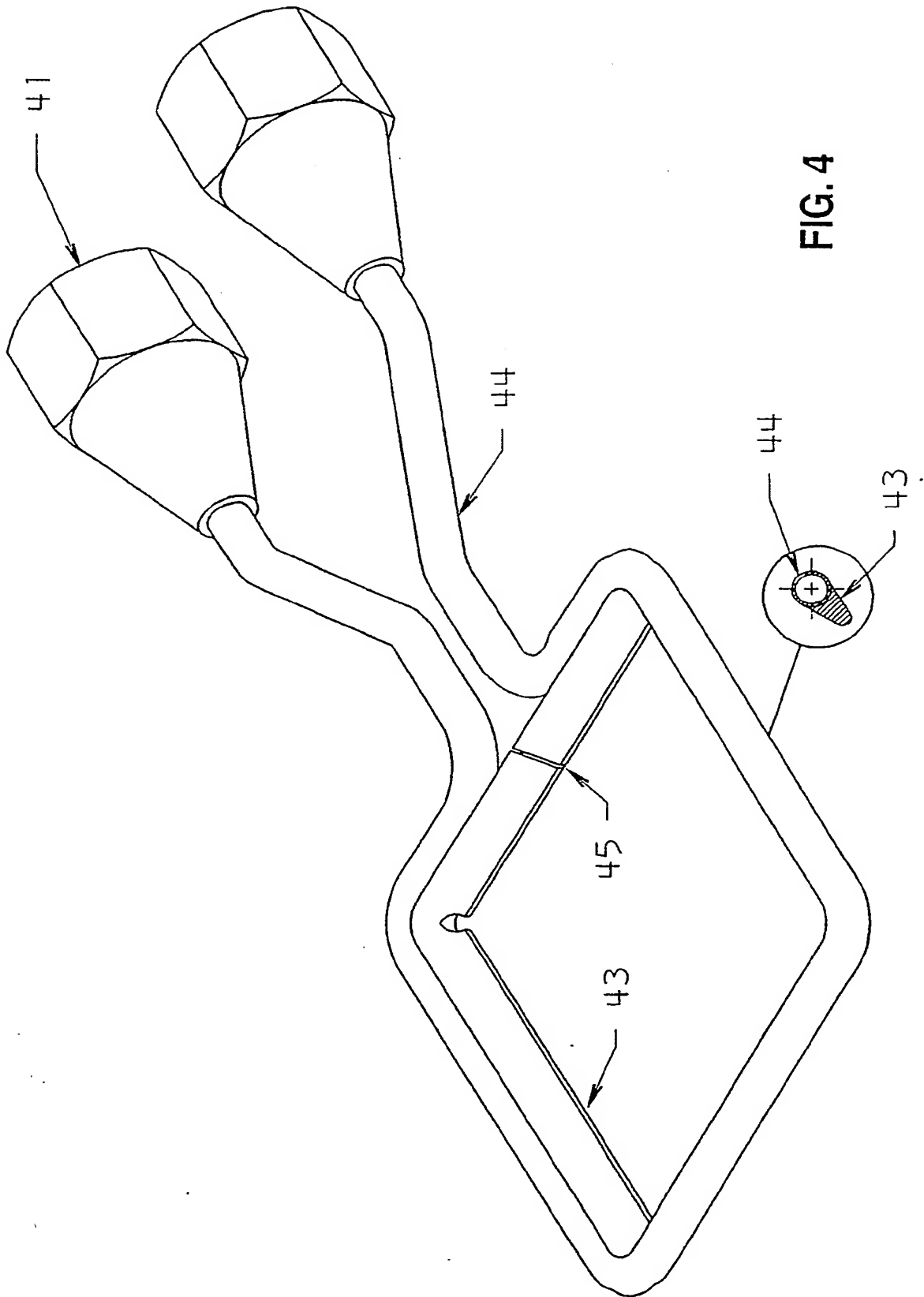


FIG. 3



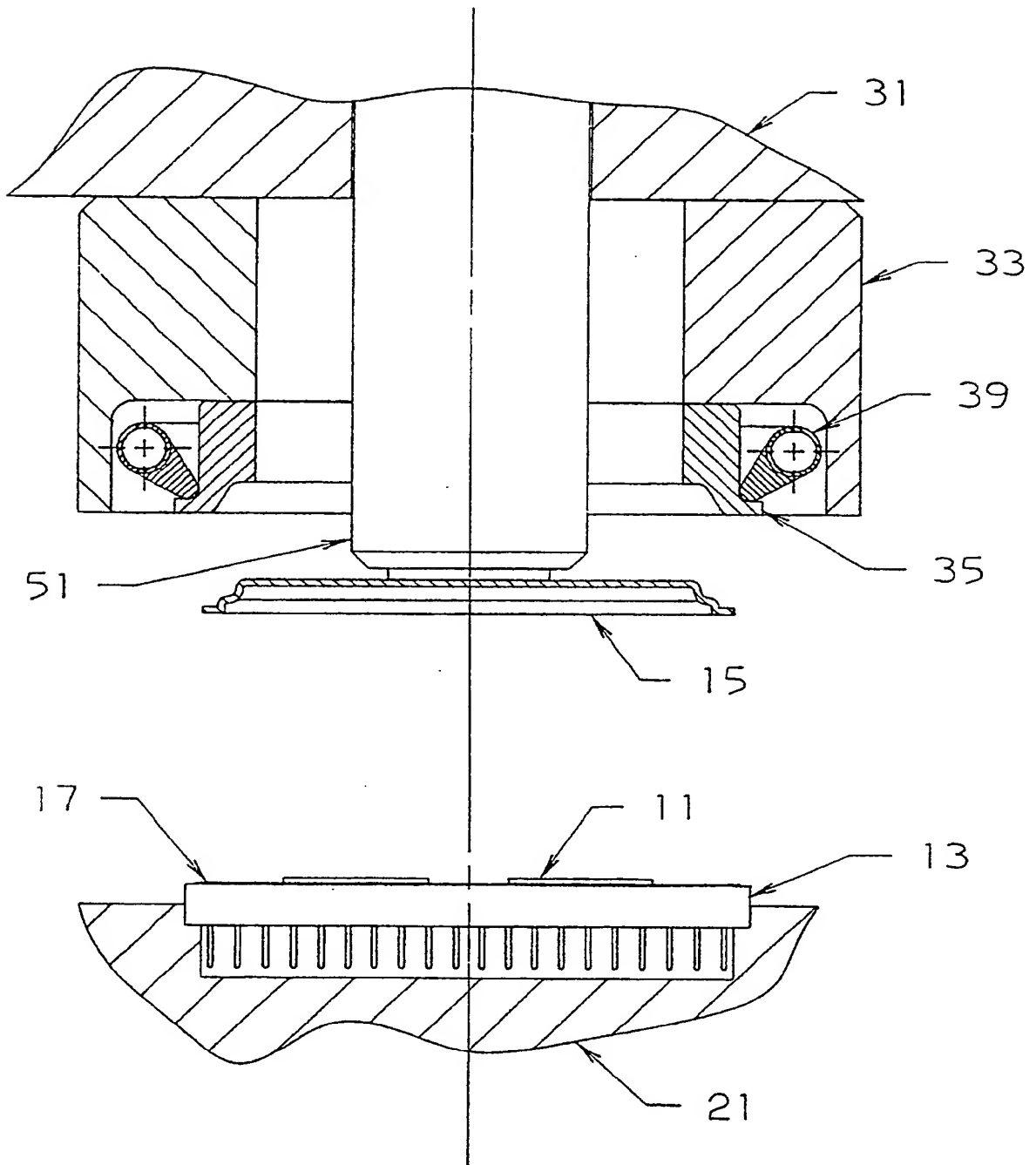


FIG. 5



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54 **Apparatus for and method using the apparatus for the encapsulation of electronic modules.**

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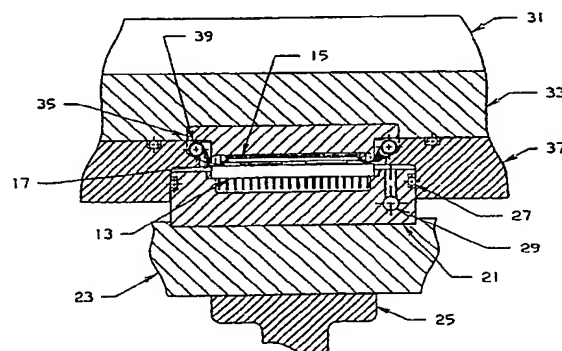


FIG. 3

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European Patent
Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 11 7426

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	PATENT ABSTRACTS OF JAPAN, vol. 8, no. 66 (E-234)[1503], 28th March 1984; & JP-A-58 218 166 (HITACHI SEISAKUSHO K.K.) 19-12-1983 * Whole abstract *	1-5,7,10,12-14	H 01 L 21/50 H 01 L 21/00
Y	PATENT ABSTRACTS OF JAPAN, vol. 6, no. 173 (E-129)[1051], 7th September 1984; & JP-A-57 90 964 (SHARP K.K.) 05-06-1982 * Whole abstract *	1-5,7,10,12-14	
Y	PATENT ABSTRACTS OF JAPAN, vol. 10, no. 87 (E-393)[2144], 5th April 1986; & JP-A-60 231 342 (KANSAI DENKI K.K.) 16-11-1985 * Whole abstract *	1-5,7,10,12-14	
A	PATENT ABSTRACTS OF JAPAN, vol. 10, no. 113 (E-399)[2170], 26th April 1986; & JP-A-60 249 349 (KANSAI NIPPON DENKI K.K.) 10-12-1985 * Whole document *	1-4,10-12	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			H 01 L
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 17-12-1990	Examiner PROHASKA G.A.F.
CATEGORY OF CITED DOCUMENTS		I : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			

EPO FORM 1503 (01.82) (P0401)



European Patent
Office

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

- ☐ All claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for all claims.
- ☐ Only part of the claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claims:
- ☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

X LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirement of unity of invention and relates to several inventions or groups of inventions, namely:

1. Claims 1-14: Sealing, package by application of RF power at the periphery of cap and/or in sealband, applying (inert) gas pressure to compensate thermal expansion of gas in housing, applying physical pressure to force cap to substrate (base).
2. Claims 15, 16: Opening of package by similar apparatus (needs an additional adaption, which is not clearly described in its functioning).

- ☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.
- ☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:
- ☒ None of the further search fees has been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims: 1-14

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